PROPOSAL FOR
APPLICATION OF EPA MODELS TO PREDICT SHORT TERM POLLUTION LEVELS DUE TO INDIVIDUAL MINES

Submitted to
**Indian School of Mines
Dhanbad**

By
**Tata Energy Research Institute
India Habitat Centre
Lodhi Road, New Delhi**

June 1999

APPLICATION FOR GRANT FOR PROJECTS UNDER THE ENVIRONMENTAL RESEARCH PROGRAMME

1. Title of the Project: APPLICATION OF EPA MODELS WITH OR WITHOUT MODIFICATIONS TO PREDICT SHORT-TERM POLLUTION LEVELS DUE TO *INDIVIDUAL MINES*

2. Name and Designation of the Principal Investigator:

    Dr. T S Panwar,
    Fellow, TERI

3. Name & Designation of the Co-Investigator:

    Dr. Subrato Sinha
    Fellow, TERI

4. Postal Address of the Principal Investigator & Co-Investigator:

    Tata Energy Research Institute,
    Darbari Seth Block, Habitat Place,
    Lodhi Road,
    New Delhi – 110 003.

    Tel. No.: 462 2246, 4601550
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5. Name of the Institution / Organisation in which the project will be carried out:

    Tata Energy Research Institute, New Delhi.

6. Name of other Institution(s) / Organisations involved in the project:

    Nil

7. Duration of the Project:

    3 Years.

8. Total amount of assistance required:

    Rs. 35,09,640/- (Rupees Thirty Five Lakh Nine thousand six hundred and forty only.)

). Following documents are enclosed:

(i) STATEMENT – I

ABSTRACT

The emphasis of large scale open cast mining has resulted in widespread concern about the deterioration in environmental quality, specially the increase in concentration of Suspended Particulate Matter (SPM) within and around the mining site. The SPM, which is the primary pollutant from the surface mining operations, is emitted due to blasting, excavation, transportation, material transfer, wind erosion of loose soil, overburden dump etc. Thus, to gain better understanding of the fate and transport of the pollutants and to predict future conditions under various "inputs" or management action alternatives, the *mathematical simulation* of the dispersion process is an important exercise. For this, application of the EPA models for the short-term prediction of the pollution levels due mining activities shall be explored. The emission inventory and meteorological data are primary inputs for an air quality model. Primary monitoring would be carried out in the study area to calibrate the model parameters. In addition hourly meteorological data shall also be collected which shall be used as input for the models. Finally, the output would be in terms of availability of validated air quality models that are applicable for Indian conditions.

(ii)   STATEMENT – II

STATE-OF-ART OF THE SUBJECT

The share of surface mining is progressively increasing in world mineral production. In India too, ore production from surface mines has been increasing through the implementation of the mechanised open cast mining technology. The emphasis of large scale open cast mining has resulted in widespread concern about the deterioration in environmental quality, specially the increase in concentration of Suspended Particulate Matter (SPM) within and around the mining site. The SPM, which is the primary pollutant from the surface mining operations, is emitted due to blasting, excavation, transportation, material transfer, wind erosion of loose soil, overburden dump etc. However, the vehicular traffic on haul road of mechanised Open Cast Mines (OCMs) has been identified as the most prolific source of fugitive dust; it can contribute as much as 60-80% of the dust emitted from a surface coal mine (Axetell and Cowherd, 1981). The uncontrolled SPM not only creates a serious health hazard but also affects the productivity through poor visibility, breakdown of equipment, increased maintenance cost and ultimately deteriorates the Ambient Air Quality in and around the mining site. Thus, to gain better understanding of the fate and transport of the pollutants and to predict future conditions under various "inputs" or management action alternatives, the *mathematical simulation* of the dispersion process is a very significant and important exercise. This is done by means of Air Quality Models (AQMs). The AQMs are necessary to estimate the changes in AAQ – both locally and at a distance – caused by a particular set of emissions and provide a quantified answer to the *"What-if"* scenario questions. AQMs, thus form an important input to the implementation of Air Quality Management Plan (AQMP) for any Air Quality Control Region (AQCR). The present proposal is an endeavour in the direction to explore the *application of U.S.*

Environmental Protect Agency (EPA) models to predict short-term pollution levels due to individual mines. The following discusses the objectives, detailed methodology, activity plan, preceded by relevant literature survey for the defined problem.

The independent/individual sources to predict the pollution levels are usually modelled as *point* sources, where as a cluster of sources within an AQCR are modelled as *area* sources. Similarly, sources distributed along a line are modelled as *line* source. As such various models have been developed to predict pollution levels, conforming to the type of source(s) encountered within an AQCR. The United States Environmental Protection Agency (USEPA) has developed several standard short-term and long-term AQMs that are available in computer code. However, the present study is restricted to short-term models, as such, only these models shall be considered here. Table 1 gives a brief summary of the various relevant models with typical distinctive features. An account of these models is, however provided in Appendix 1 for reference. Many of these models are being routinely used in Environmental Impact Assessment (EIA) studies and form the basis of regulatory air quality modelling (Sawford and Ross, 1985).

DETAILED LITERATURE SURVEY

The air dispersion models are mostly used to model the short- and long-term pollution levels of isolated point source such as industrial chimney, line sources (e.g. vehicular exhausts) and area sources (e.g. clusters of point source in an AQCR). However, the application of the AQMs to model the air pollution concentrations due to large sources such as OCMs is relatively rare.

Shearer et al. (1981) compared the short-term (6-h) and long-term (annual average) Total Suspended Particulate (TSP) concentrations with ISCST and ISC-Long-Term (ISCLT) models respectively, near the Belle Ayr Mine in Wyoming, U.S.; the study was a part of Emission factor Development Study (EDS). For short-term periods, examination of 48 data pairs indicated that agreement of measured/modelled concentrations was within a factor of two 41% of the time; and

Table 1   A brief outline of the various short-term prediction EPA models

Model	Features and Special Remarks
ISCST3	Model can account for settling and drying deposition of particulates, downwash, area, line and volume sources. Average concentration or total deposition may be calculated in 1-, 2-, 3-, 4-, 6-, 12- and/or 24-hour time periods. The model has option to access emissions form surface mining operations.
PAL and PALDS	Calculates hourly pollutant concentrations from point, line and area sources. PALDS, the modified PAL model has the capability to explicitly treat the effects of gravitational settling and /or deposition loss of pollutant on calculated concentrations.
FDM	Computes concentration and deposition impacts from fugitive dust sources; the sources may be point, line and area sources. The gravitational settling velocity and deposition velocity can be computed for each class.
MPTER	Multiple point-source model with optional terrain adjustments. Most applicable for source-receptor distances < 10Kms. Estimates hourly concentration for relatively inert pollutants like SO_2 and TSP.
MPTDS	Modification of MPTER; takes into account explicitly for gravitational settling and /or deposition loss of a pollutant.
SHORTZ	Claculates pollutant concentrations at large number of receptors due to emissions form multiple stacks, building and area sources; applicable in both flat and complex terrain.
VALLEY	Calculates 24-h and annual average concentrations from emissions from upto fifty point and area sources.
PTMAX	Performs analysis of the maximum short-term concentrations from a single-point source as a function of stability and wind speed.
PTPLU	Estimates maximum surface concentrations for 1-h concentrations; an adaptation and modification of PTMAX that allows wind profile exponents and other optional calculations, such as buoyancy-induced dispersion, stack downwash and gradual plume rise.
RAM	Estimates concentrations for stable pollutants from urban point and area sources; special features include the determination of location of uniformly spaced receptors to ensure good area coverage with minimum number of receptors.
PTDIS	Estimates short-term concentrations directly downwind of a point source at distances specified by the user; isopleths half widths for specific concentrations at each downwind distance can be calculated.
PTMPT	Estimates the concentration for a number of arbitrarily located receptor points at or above ground-level, from a number of point sources; plume rise can be determined for each source.

within a factor of three for 56% of the pairs. Other significant studies, though carried for long-term prediction are Komp et al. (1984) and Dailey (1984).

Perry et al., conducted a wind tunnel study to simulate environmental impacts of open cast mining operations to assess the ISCST2 model for application to OCM to highlight the important parameters to consider for modelling; the study indicated that open pits act as modified area sources where the emissions are greatest near the upwind side of any actual pit.

The performance of two mathematical models, the Fugitive Dust Model (FDM) and ISCST (and ISCLT) in predicting the TSP concentrations at 22 monitoring sites around two groups of OCMs in the Powder River Basin of Wyoming was examined by Vardiman and Winges (1991). Predictions were made for both short-term (24-h) and long-term (annual average) concentrations. Each model also used two sets of emission rates, one calculated from EPA emission factors published in AP-42 (USEPA, 1985/1986/188/1990/1991) and a second set developed by the State of Wyoming Department of Environmental Quality, Air Quality Division. Though the annual average predictions were quite satisfactory, the performance of both the models was found to be unsatisfactory. Later, Irwin and Touma (1992) extended these analyses by comparing the observed and predicted second high 24-h TSP concentration values in space (at the 22 monitoring locations in the Powder River Basin). Two dispersion models and different sets of emission factors were used to generate predicted TSP concentrations at the monitoring sites. The study revealed that the model predictions were within a factor of two, typical of Gaussian dispersion models. Tikvart (1991) and Addison (1999) approve the use of ISC, from purely technical standpoint, for regulatory modelling of the OCMs such as coal mine emissions. Further, three reports (USEPA, 1994a,b,c) have been prepared under Section 234 of the amended U.S. Clear Air Act which requires EPA to analyse the accuracy of the ISC models and AP-42

(USEPA, 1985/1986/1988/1990/1991) to determine the effect on air quality of fugitive particulate emissions. The study, an exhaustive one, also approves the application of the ISC models for OCMs.

In India very less attempts have been made in quantifying the level of dust concentration in and around the surface mines by using the mathematical models. The major reason of this is the lack of availability of emission factors for the different sources in surface mines. Few attempts have been made by the researchers of the Indian School of Mines (ISM) to quantify the emission factor for haul roads and other resources by using the exposure profiler techniques and various empirical formulas developed by US EPA and Australian EPA. Few attempts have been made to assess the impacts of dust emanating from haul roads on the ambient dust concentration by using the mathematical model by ISM and Central Mining Research Institute (CMRI). Some consultants have also tried to do mathematical modelling to assess the impacts of surface mines on ambient dust level as part of the preparation of EIA. But most of the cases it required additional research effort to build up confidence in the application of such models. Keeping this into consideration, the current study focuses on the necessity to have validated AQMs for the prediction of impacts due to mining operations. In this regard, EPA models, which are already widely used world over, are intended to be applied in the Indian conditions.

It may also be noted here that the CPCB has evolved guidelines for conducting air quality modelling for impact assessment purposes (CPCB, 1996), which shall also be kept into consideration while carrying out the modelling exercise.

OBJECTIVE

Application of EPA models with or without modifications to predict short-term pollution levels due to mining activities in individual mines.

DETAILED METHODOLOGY

The section provides a comprehensive discussion on the methodology to be pursued to meet the identified objectives. To have a better perspective, various steps involved have been described under different heads in logical sequential manner.

Literature Review

Relevant literature pertaining to the *emission rates* and *air quality models* shall be collected during the course of the study.

Identification of Sites and Planning

The modelling activity shall be carried out for individual iron ore mines, for example located in Goa. A preliminary reconnaissance survey shall be first conducted to identify the *"present status"* of the AQCR, in terms of terrain geometry, identification of source emissions, existing pollution control strategies, availability of AAQ and meteorology data, if any, identification of most appropriate sites for AAQ and meteorological stations and so on. Thus, for instance a study of the source activity shall focus on rough estimation of contribution of various open cast mining operations such as movement of materials e.g. iron ore, dragline transfer of overburden, haul truck transport of ore and overburden, scrapper transport of topsoil, miscellaneous medium and light duty traffic on haul and access road etc. In addition, likely sources of background concentration shall also be identified. This shall be helpful in narrowing down the alternative strategies to solve the problem and thus enable the adoption of efficient methodology.

Emission Inventory

Emission source inventory, which identifies and locates the emission sources of interest and assigns emission rates to each source, is the most important and critical input for an AQM.

The performance of a model is directly dependent on the source emission rates. To arrive at accurate emission factors, identification of likely sources of emission is important. Table 2 summarily presents different source categories, their operating characteristics and classification as point, line, area or volume source (USEPA, 1994b).

Table 2   Source representation

Source category	Operating characteristics	Representation
Haul roads	Fixed routes	Line sources
Loading and dumping activities of ore and overburden.	Mobile within definable areas that are fixed at ends of ramps to haul roads	Point source
Wind erosion from ore and overburden dump	Definable areas of surface disturbance where excavation /traffic are occurring	Area source
Drilling	-	Point source
Blasting	-	Point source

Primary Monitoring

The end use of monitoring data governs the design of atmospheric monitoring network. It is, therefore instructive to first outline the clear monitoring objectives for which the monitoring network is to be designed. Thus, following objectives have been identified for AAQ and meteorology data, based on which the monitoring network shall be designed.

Air Quality Data

❖ To develop a reliable air quality data base for calibration and validation of EPA models for short-term prediction of pollution levels from OCMs.

❖ To make air quality impact statements due to open cast mining operations.

Meteorology

❖ To provide meteorological data to assist in characterising the dispersion phenomena associated with fugitive dust sources from open cast mining operations.

❖ To provide requisite input to the EPA models for quantifying the AAQ.

Thus, a monitoring plan spread over four seasons, with a representative one month per season is envisaged. For each representative month 24-h monitoring would be carried out twice a week for 4 weeks. During each of this 24-h monitoring, 8-h samples corresponding to each shift shall be collected. This data set would be particularly useful since it would help to analyse shift wise variation in dust level and would be certainly helpful in terms of AAQ modelling. Besides TSP, some samples of PM-10 would also be collected so as to get a better insight into the ratio of PM-10 to the TSP. In addition, efforts would also be made to collect data from existing AAQ stations near the mining area, wherever possible. Tentatively, 10 monitoring stations are presently planned to carry out the monitoring activity (minor changes can be made based on the reconnaissance survey etc.). Table 3 provides a brief summary of the monitoring activity.

Table3   Summary of Monitoring Activities

Monitoring type	Data type	Source	Significance/Function
AAQ monitoring stations (10)	AAQ data	Primary	Integrated air quality at appropriate receptor locations; for model calibration and validation
Meteorology data	Wind vector, ambient temperature, humidity	Primary	Data required for direct model input requirements
	Mixing height	Secondary (nearest local Indian Meteorological Department station)	

Modelling

The next step is the air quality modelling exercise, which forms the primary objective of the proposed study. A complete modelling system, for the purposes of modelling shall be defined in terms of AQM, emission inventory and geometric representation of the system. Based on the

relevant literature survey, studies conducted in the past and features of various EPA models, the ISCST3, FDM and PAL (with its modified version PALDS, which also takes into account the effects of gravitational settling and/or deposition loss of calculated concentrations) models were found to be most suitable for the proposed study. Thus, a comparative assessment of these three models shall be done and in the final analysis a statement on the suitability of the model(s) specific for open cast mining operations shall be made.

The *Particle Size Distribution* (PSD) is an important factor that governs the model performance,which is required to develop the essential inputs to the deposition module of the AQMs. The inputs are usually expressed in terms of the gravitational settling velocity distribution and the surface reflection coefficient distribution; these factors are computed from the PSD. Thus, PSD shall be prepared, covering the major sources, which shall be used to characterise emissions from all modelled sources. This is so because, as stated earlier, the haul road emissions account for more than half of the total emissions and various categories of fugitive dust sources exhibit almost same particle size profiles (EPA, 1994a). The emission factors to be input in the AQMs will be used as given in the EPA's *Compilation of Air Pollutant Emission of Air Pollutant Emission Factors, AP-42* (USEPA, 1985/1986/1988/1990/1991), U.S. Beauru of Mines, Australian EPA and based on the empirical formula and other relevant literature review (Sinha, 1994). Various AQMs would then be *calibrated* using the data base for the selected AQCR.

Model Performance Evaluation and Validation

The monitored AAQ data would be used to validate the different AQMs used in this study. Various statistical indices for model performance evaluation would also be used. These may include Factor of two, Coefficient of determination, coefficient of agreement (Willmott, 1981 and Willmott et al., 1985), RMSE, geometric variance, robust highest concentration (Cox and Tikvart, 1990)

Table 4 Work plan for the proposed Project

Activities	1st year				2nd year				3rd year			
	1st qr.	2nd qr.	3rd qr.	4th qr.	1st qr.	2nd qr.	3rd qr.	4th qr.	1st qr.	2nd qr.	3rd qr.	4th qr.
Literature review	■	■	■									
Procurement of instruments and models		■	■	■								
Visiting site and finalisation of programme			■									
Progress report for the 1st year				■								
Primary monitoring					■	■	■	■				
Progress report for the 2nd year						■		■				
Testing of models						■						
Modelling exercise							■	■	■	■	■	
Final report												■

PRACTICAL RELEVANCE/UTILITY OF THE PROJECT

The proposed project shall provide better insight and understanding of the dispersion phenomenon of particulate matter emanating from different sources in the mining areas, where very less work has reportedly been done in Indian conditions. The understanding would help in the development of appropriate environmental management plans for area quality control region.

AGENCIES WHICH CAN UTILIZE THE RESULTS OF THE PROJECT

The research output would be useful not only for the researchers but also for other planning and policy makers and implementing agencies viz. Ministry of Coal, Ministry of Environment and Forests, Regional Office, CPCB, SPCB, State Governments, and Research Institutes like ISM – Dhanbad, IIT's, etc.

(iii)   STATEMENT – III

RESEARCH TEAM

Mr. P.V. Sridharan, who has a mining background and has over 30 years of experience, would act as advisor for this project. Dr. T.S. Panwar, who is currently working as Fellow and Area Convenor, Centre for Environmental Studies and has expertise in Air pollution Modelling would be the Principal Investigator for the study. Dr. Subrato Sinha, Fellow, TERI, who has been working in the field of mining environment and related air quality issues, would be the Co-Investigator for the proposed study. Dr. Prateek Sharma and Mr. Amit Kapur, Research Associates would be the other team members for this study. Dr. Prateek Sharma has special expertise in Environmental Systems Modelling and Mr. Amit Kapur has good background in Environmental monitoring and data analysis. The detailed CVs for the team members are enclosed.

Curriculum Vitae

Name of Firm	:	Tata Energy Research Institute
Name of Staff	:	P V Sridharan
Profession	:	Research & Consultancy - Energy and Environment
Date of Birth	:	August 20, 1940
Years with Firm	:	13 Nationality : Indian

Membership of Professional Societies:

- Life Member of Mining, Geology and Metallurgical Institute of India, Calcutta
- Life Member of Indian Institute of Public Administration, New Delhi
- Member of All India Management Association, New Delhi

Detailed Tasks Assigned:

- Environmental advisor.

Key Qualifications:

- Regional Environmental Management.
- Energy-environment interface.
- Energy/Environmental policy studies.
- Environmental issues in mining & coal sector.

Mr. P V Sridharan is a mining engineer and senior fellow at TERI with over 30 years experience in the Indian coal sector.

He started his career as a mine manager in private sector mine where he was intimately associated with day to operation at the grass root level. He was in-charge of production, planning and safety and was responsible for implementation of mine related acts and regulations.

In 1973, the industry was nationalized and he was placed in Central Coalfields Ltd. where he has been working with the Chief Executive where he got a wide and varied knowledge at the corporate level. As Secretary to CCL Board, he was involved in formulation of long term policies and plans for the coal major.

He was Deputy chief Mining Engineer & Secretary to Board at Central Coalfields Ltd. when he joined TERI on deputation for pursuing research in energy and environment. He later resigned from CCL and joined TERI as fellow.

In TERI, he has been involved in many projects, both as in-charge and as advisor covering various issues in coal sector namely demand forecasting; supply issues; efficiency of utilization of coal, pricing, distribution, transport. environmental impacts of coal mining, etc. In addition he has been project team leader on several area-wide environmental impact assessment studies including mining areas namely Jharia - Dhanbad, Neyveli and recently the iron ore belt of Goa state.

Some of the major projects on environment, successfully completed by him, are Rapid EIA/EMPs for Utkal-A coal mine, sponsored by M/s. Kalinga Power Corp., Bina opencast coal mine, sponsored by Asian and Pacific Development Center, Malaysia, Integrated EIA/EMP for the Neyveli Master Plan Project in association with M/s LAUBAG Consulting, Germany, sponsored by NLC and Area wide EMP for Iron ore belt of Goa sponsored by the State.

- Non-coking coal beneficiation prospects in India for the Indo-US coal preparation programme.
- Techno-economic study of coal washeries for cement industry, sponsored by CMPDI.
- Mathematical models for demand forecasting of coal sponsored by CMPI.

Coking coal supplies to steel plants. An economic analysis of indigenous supplies vis-à-vis imported coal, sponsored by Coal India Limited.

His current interests are in policy issues in the area of energy in general and coal in particular and its interface with environment. Area wide Environmental Quality Management (AEQM), which adopts a holistic approach towards environmental management in a given region and account for contribution of emissions from all sources including industrial sources, is one of his areas of specialisation.

Related Projects

Environmental related

- Area-wide Environmental Quality Management Plan for the mining belt in Goa, sponsored by Government of Goa.

- Master plan for environmental quality management for Dhanbad-Bokaro region, sponsored by United Nations Industrial Development Organization, Vienna, Austria.

- Preparation of Integrated EIA and EMP for the Neyveli Master Plan Project in association with M/s. LAUBAG Consulting, Germany, sponsored by Neyveli Lignite Corporation.

- Rapid EIA/EMP for Utkal-A coal mine, sponsored by M/s. Kalinga Power Corpn.

- Environmental considerations and options in managing India's long-term energy strategy sponsored by the United Nations Environment Programme (UNEP).

- Environmental issues in coal mining and associated costs, sponsored by Bureau of Industrial Costs and Prices, Government of India.

- Environmental considerations in energy development: India country study, sponsored by Asian Development Bank (ADB).

- Rapid EIA study of Bina opencast coal mine, sponsored by Asian and Pacific Development Centre, Malaysia.

Coal sector related projects

- Inter-fuel substitution for power generation, sponsored by ERM (India).

- India-South West coast gas market study, sponsored by SHELL International.

- Eastern India market study for natural gas, sponsored by SHELL International.

- Waste heat recovery potential from bee-hive coke oven gases in a pig iron plant, sponsored by Usha (India) Ltd.

- Role of coal in Indian energy scenario, sponsored by Coal India Ltd.

- Non-coking coal beneficiation prospects in India for the Indo-US coal preparation programme sponsored by Burns & Roe Inc. USA.

- Techno-economic study of coal washeries for cement industry, in association with Central Mine Planning and Design Institute (CMPDI), sponsored by Department of Industrial Development, Government of India.

- Evaluation of coal briquettes and SSF (Special Smokeless Fuel) as domestic fuels, sponsored by Coal India Limited.

- Efficiency of coal utilization in boilers in selected industries in the eastern region, sponsored by Coal India Limited.

- Mathematical models for demand forecasting of coal, sponsored by CMPDI.

- Coking coal supplies to steel plants: an economic analysis of indigenous supplies vis-à-vis imported coal, sponsored by Coal India Limited.

- Efficiency of coal and oil consumption in Panipat Thermal Power Station, sponsored by Haryana State Electricity Board.

- Energy options for South India: with specific reference to power generation and lignite resources sponsored by Neyveli Lignite Corporation Limited.

Education:

- Post Graduate Diploma in Management, All India Management Association, 1986
- First Class Colliery Managers' Certificate, Directorate General of Mines Safety, Dhanbad, Bihar, 1969
- B.Sc. (Hons.) in AISM Mining Engineering, Indian School of Mines, Dhanbad, 1963

Employment Record:

1991 – till date	Senior Fellow, TERI, New Delhi
1989 – 1991	Dean, Energy Policy TERI, New Delhi
1986 – 1988	Fellow, TERI, New Delhi
1983 – 1986	Central Coalfields Ltd., Ranchi, Bihar, Deputy Mining engineer & Secretary to Board
1976 – 1983	Central Coalfields Ltd., Ranchi, Bihar, Second in command in Technical Secretariat of Chairman. Responsible for liaison with various departments on behalf of the chairman for smooth implementation of the overall plans of the company.
1973 – 1975	Central Coalfields Ltd., Ranchi, Bihar
1963 – 1973	Worked for private sector coal mines, in various positions involving both operation and planning. Involved in implementation of Mines Act, Rules and Regulations framed thereunder at the grass root level. Responsible for planning, production, safety and welfare.

Languages:

	Speaking	Reading	Writing
English	Excellent	Excellent	Excellent
Tamil	Excellent	Excellent	Excellent
Hindi	Excellent	Good	Fair

Curriculum Vitae

Name of Firm	:	Tata Energy Research Institute
Name of Staff	:	Dr. T S Panwar
Profession	:	Environmental Scientist
Date of Birth	:	October 20, 1963
Years with Firm	:	4.5 Nationality: Indian

Membership of Professional Societies:

- Member of Indian Association of Environmental Management

Key Qualifications:

Currently working as fellow at TERI. His key areas of expertise are

- Air quality modelling.
- EIA/EMP studies.
- Acid Rain.
- Risk assessment studies.

Education:

- Ph.D., Air Pollution Modelling, I.I.T, Delhi, 1993. Thesis: 'Mathematical models to study atmospheric dispersion of denser than air toxic materials for estimating vulnerable zones'
- M.Sc, Physics, I.I.T, Delhi, 1986
- B.Sc, Physics, Chemistry, Maths, University of Delhi, 1984

Employment Record:

1998 - till date   Fellow and Area Convenor, Centre for Environmental Studies, TERI. Currently involved in Acid Rain related studies - EU sponsored project on role of renewables in air pollution abatement. Results of this study will be integrated in the RAINS-Asia model. Also working on another project involving the study of the environmental impacts of various fuels used for power generation. Have also been appointed by the ADB as the National Coordinator for India for the project Acid rain and emissions reduction in Asia, Ph. II. Other responsibilities include project monitoring, proposal coordination, area activity planning, and human resources development.

Dec. 1994 - 1997   Fellow/ Research Associate at the Tata Energy
Research

Institute (TERI), New Delhi. (Total duration: 3 years)
Worked in the Energy Environment area of TERI on
research projects related to air quality modelling,
EIA/EMP studies, acid rain, air pollution studies
(current scenario, causal factors and remedial
measures), and coordinator of training programme on
energy, environment and sustainable development.

Jul. 1986 –
Dec. 1994   Senior Scientific Officer (SSO-II), Senior Research
Associate (SRA), and Research Scholar at the Indian
Institute of Technology (IIT), New Delhi. (Total
duration: 8.5 years) Worked on research projects related
to air quality modelling, EIA studies, risk assessment
studies, acid rain and atmospheric dispersion studies.

Related Projects

- Principal Investigator (PI) for the Indian component of the project
  "Potential for use of renewable sources of energy in Asia and their cost-
  effectiveness in air pollution abatement". Project sponsored by the
  European Commission. Besides TERI, the other research teams include
  WIMEK (Netherlands), IIASA (Austria) and ERI (China). Project ongoing
  since January 1997. Results of the project would be subsequently
  integrated in the RAINS-Asia model.

- Team Member, preparation of a dossier on environmental impacts related
  to the use of Orimulsion for power plants, 1999. Project sponsored by MC
  Bitor Ltd., Japan.

- National Coordinator for India for the technical assistance project "Acid
  rain and emissions reduction in Asia" funded by the ADB, 1998-99.

- Air pollution in India (comprehensive study covering current air pollution
  scenario in various cities in India, trends, causal factors and remedial
  measures), as part of the GREEN INDIA 2047 project of TERI, 1997.

- Team member of the project "Master Plan for Neyveli Area". Report
  "Volume VI - Environment" submitted by TERI to LAUBAG-Consulting,
  Germany, Dec. 1995. Responsible for the **air quality modelling** work and
  the associated environmental impacts of the proposed power plants in
  Neyveli region, Tamil Nadu.

- Associated in the **air quality modelling** part of the project "Area-wide
  environmental quality management (AEQM) plan for Dhanbad-Bokaro
  area", Final report (92/EE/53) submitted by TERI to UNIDO (January
  1996).

- Team member of the report "**Concentration Fluctuation Models**: A Comparative Study", Technical Report of the Dept. of Engineering, Cambridge University, U.K., Report No. CUED/A - AERO/TR 24, May 1994. Responsible for the research work related to the intercomparison of various models, model calculations, data analysis and report writing.

- Team member of the project Environmental Impact Assessment (Air Quality) of proposed 500 MW Thermal Power Plant in Mangrol Area of Chittorgarh District, Rajasthan. Report submitted to M/s. Century Textiles & Industries Ltd. by IIT Delhi. Responsible for **air quality modelling** and impact assessment study.

- Team member of seven reports entitled "Vulnerability analysis due to accidental release of Chlorine, Ammonia, HCN, Phosgene, Anhydrous Hydrogen Fluoride, Carbon disulphide and Ethylene Oxide". These seven reports, one for each chemical, were submitted to the Ministry of Environment and Forests (MoEF), New Delhi by IIT Delhi. Responsible for **modelling the dispersion scenario due to the accidental release of these hazardous chemicals and analysis of the Vulnerable zones.**

- Team member of the project Zone of influence due to accidental release and leakages of Chlorine at SFFI, Delhi; Ammonia at GSFC, Baroda; and HCN at IPCL, Baroda. Report submitted to Defence Research and Development Establishment (DRDE), Gwalior by IIT Delhi. Responsible for **the air quality modelling part and the determination of the zone of influence.**

- Member of the air pollution team at the Centre for Atmospheric Sciences, IIT Delhi for determining the dispersion parameters using tracer gas experimental techniques.

- Principal Investigator (PI) of the project "The impacts and costs of air pollutants on crop yields in developing countries", Report (No. 96/EE/51) submitted by TERI, New Delhi to Imperial College, U.K., Dec. 1996. Besides project coordination, responsibility included the compilation and analysis of the air pollution data for India.

- Co-ordinator of the 1996-97 batch of the Programme on Energy, Environment, Resources and Sustainability (PEERS) conducted annually by TERI, New Delhi. This programme focuses on capacity building in the area of sustainable development, and includes the interlinkages between energy, environment and resource utilization. It targets mid-career professionals from the government, corporate sector, academic institutes, media and NGO's. In addition, a few participants from other South-Asian/Central-Asian countries are also included. The total programme duration is 9 weeks, spread over three phases. The first and third phase of the training are conducted at New Delhi while the second phase is conducted in USA. One of the key component of the programme is the design and implementation of specific project by each participant based on

sustainability principles in his/her work areas. Responsible for coordinating the 1996-97 batch of PEERS.

Languages:

	Speaking	Reading	Writing
English	Excellent	Excellent	Excellent
Hindi	Excellent	Good	Good

Certification:

I, the undersigned, certify that to the best of my knowledge and belief, this bio-data correctly describes myself, my qualifications and my experience.

Signature

_____

Signature of Staff Member or
Authorized official from the firm

Date: __28 | 6 | 99__

Day/Month/Year

List of Research Publications (T S Panwar)

i) M.P.Singh, P.Goyal, **T.S.Panwar**, P.Agarwal and S.Nigam: "Predicted and observed concentrations of SO_2, SPM and NO_x over Delhi". Atmospheric Environment, Vol.24A, No.4, pp. 783- 788, 1990.

ii) M.P.Singh, P.Goyal, S.Basu, P.Agarwal, S.Nigam, Manju Kumari and **T.S.Panwar**: "Predicted and measured concentrations of traffic Carbon-monoxide over Delhi". Atmospheric Environment, Vol.24A, No.4, pp. 801-810, 1990.

iii) **T.S.Panwar** and M.Hayashi: "A Field Diffusion Experiment System in Short Range". Pollution Control, Vol.26,No.1, pp.65-79, 1991.

iv) M.P.Singh, Manju Mohan, **T.S.Panwar** and H.V.K.Chopra: "Atmospheric Dispersion of dense materials for estimating vulnerable zones due to accidental release of toxic chemicals". Risk Analysis, Vol. 11, No. 3, pp. 425-440, 1991.

v) Manju Mohan, M.P.Singh and **T.S.Panwar** : "Atmospheric Dispersion of inflammable substances for estimating vulnerable zones in hydrocarbon industry". Risk Analysis, Vol. 11, No. 3, pp. 419-423, 1991.

vi) Manju Mohan, **T.S.Panwar** and M.P.Singh: "Development of Dense Gas Dispersion Model for Emergency Preparedness", Atmospheric Environment, Vol.29, No.16, pp. 2075-2087, 1995.

vii) **T.S.Panwar** and Manju Mohan: "Release Rate estimation for various Accidental Scenarios", Journal of the Inst. of Engrs. (India) EN, Vol. 75, pp.49-54, Feb. 1995.

viii) **T.S.Panwar**, I.R.Cowan and R.E. Britter: "Concentration Fluctuation Models : A Comparative Study", Technical Report of the Dept. of Engineering, Cambridge University, U.K., Report No. CUED/A - AERO/TR 24, May 1994."

ix) **T S Panwar**, D D Bhujanga Rao and S Sreekesh: "Ambient Air Quality status of various cities in India", I J E P, Vol. 17, No. 11, pp. 841-845, 1997.

x) Manju Mohan, **T S Panwar** and B R Gurjar: "Impact assessment and mitigation strategy for air quality change due to TPP: a case study", I J E P, Vol. 18, No. 11, pp. 801-815, 1998.

Tata Energy Research Institute

1. **Name:** Subrato Sinha

2. **Date of Birth:** 25 November 1967

3. **Current Employer:** Tata Energy Research Institute   **Years with Current Employer:** 5

4. **Current Position:** Research Fellow

5. **Professional Designation:** Environmental Engineer

6. **Area of Specialization:** Industrial Air Pollution

7. **Proposed Position on Team:** Environmental Expert

8. **General Qualifications:**

8.1 Education and Training:
- Ph D, Environmental Engineering, Indian School of Mines, Dhanbad, 1995
- M Tech, Open Cast Mining Engineering, Indian School of Mines, Dhanbad, 1992
- B Engg, Mining Engineering, Calcutta University, 1990

Key Qualifications:
- Regional environment management plan
- Environmental impact assessment
- Industrial air pollution

Professional Societies Membership
- Life member, Indian Meteorological Society, New Delhi
- Life member, Mining, Geological and Metallurgical Institute of India
- Life member, Mining Engineers Association of India
- Member, Indian Association for Environmental Management
- Member, Mining and Environment Research Network, UK

8.2 General Experience:

1998-Till date	Fellow, Centre for Environmental Studies, TERI, New Delhi. Working on projects related to environmental and social performance indicators and sustainable markers for mining industry, environmental indicators, natural resource accounting, air pollution assessment and control studies.
March 1998-94	Research Associate, Centre for Environmental Studies, TERI. Worked on projects related to regional environmental management studies, environmental impact assessment (Power Plant, Mining), Air pollution control studies in mining & small scale sectors, Generation of emission factor (surface mines), Natural resource accounting.
1992-1994	Research Fellow. Indian School of Mines, Dhanbad. Worked on projects related to air and noise quality assessemnt and modelling, dust control in mines, ground and body vibration.

9. Competence for proposed work

9.1 Related Experience:

Projects

1999

Principle Investigator, **Investigation on respirable particulate and trace elements with source identification in air environment of Korba,** Sponsored by Ministry of Coal, Government of India, New Delhi. Study includes carry out measurement of total suspended particulate matter and respirable particulate matter for four seasons, determine various trace elements in airborne particulate matter and contribution of trace elements from different natural and anthropogenic sources, assess miners exposure levels in opencast mines and indoor exposure levels in households in residential colonies and recommend appropriate actions for reducing pollution in the area-ongoing.

Team member, **Environmental/social performance indicators (ESPIs) and sustainability markers in minerals development: reporting progress towards improved ecosystem health and human wellbeing.** The study would assess the influence of mining on ecosystem health dynamics where ecosystem is made up of the domains of socio-political, socio-cultural, economic and biophsical. Three indicators would be developed to arrive at the composite indicator i.e. a sustainable mining and development index. These three indicators are environmental performance indicators at the company level, well being indicators at the community level and good governance indicators at the government level-ongoing.

1998

Principle Investigator, **Workshop on Regional Environmental Management Plan**, sponsored by Ministry of Environment and Forest, Govt. Of India. Coordinate and organise workshop, prepare the workshop recommendations, and bring out edited proceedings.

Principle Investigator, **Review of the environmental guidelines prepared by the World Bank for new thermal power plants**, sponsored by The World Bank, New Delhi, India. Review with special emphasise on technical, economic and institutional implications of the guidelines on Indian positions. **Organise a workshop.**

Team member, **Assessment of the effectiveness of funding under United Nations Development Programme (UNDP)\Regional Bureau for Asia and Pacific (RBAP) programmes on environment and natural resource management.** Study includes identification of principle impediments to smooth and expeditious implementation for improved delivery of resources to countries in the region, provide recommendation on indicators and benchmarks for guiding and monitoring outlines, evolve a medium to long range strategy to position RBAP\UNDP programmes on environment and natural resources.

Team member, **Action research programme on improvement of energy-environment efficient technology in Howrah foundry cluster**, funded by Swiss Agency for Development and Cooperation (SDC). Study the system dynamics exist in the cluster, prepare report on macro and micro level environment, emission inventry and environmental strategy.

1997   *Team member*, **Area wide environmental quality management (AEQM) plan for Goa Iron ore mining belt**, funded by Govt. of Goa. The AEQM plan may guide the activities of the State Government in its efforts to reduce environmental degradation in the mining belt. The AEQM strategies would be characterised by cost effectiveness, persuasiveness, implementability and innovativeness. The plan covers a period of 15 years (1997-2012).

Team member, **Natural Resource Accounting for National Capital Region**, sponsored by Ministry of Environment and Forest, Government of India. Prepare physical and monitory accounting for mineral component.

1996   *Team Member*, **Environmental imapct assessment and environmental management plan for Utkal-A mine, Talcher coalfield**, sponsored by Kalinga Power Corporation, Orissa. Assessment of existing status of environment namely air, water, noise, soil and land use and socio-economic parameters. Predict the possible adverse impacts of the proposed mining project on the environment and on the population over a 10 km surrounding the project. Prepare an environmental management plan to mitigate the adverse effect of the project.

Team member, Survey of slag utilisation in India, sponsored by Nomura Research Institute Limited, Japan. Collection and analysis of data, prepare report.1996.

Team member, **Air pollution study of an office building, funded by Paharpur Business Centre, New Delhi**. Indoor air quality and pollution sources were studied and correlated with ambient air quality. Performance of the air handling units were studied to explore the possibility to improve indoor air quality.

Advisor, **The impacts and costs of air pollutants on crop yields in developing countries**, submitted to Imperial college, UK.

1995   *Team member*, **Integrated Environmental Impact Assessment & Environmental Management Plan for Neyveli Master Plan project.** sponsored by Neyveli Lignite Corporation, Neyveli. Preparation of an EIA report identifying possible adverse effects of the master plan project activities due to mining, power generation and other industrial activities on the environment namely climate, air quality, surface and ground water quality, water balance, noise levels, ground vibration levels, flora, fauna, land use and socio-economic conditions. The time horizon selected for the study is 2020. Preparation of an EMP for the protection of the above environmental parameters.

1994   **Ph D project on characterization and control of haul road dust in open cast mines**, funded by Ministry of Environment and Forests, Govt. of India through Centre of Mining Environment, ISM, Dhanbad. Characterisation of physical, chemical and mineralogical properties of fugitive dust emanating from line sources in surface mines. Estimation of emission factor for vehicular traffic on unpaved haul road. Evaluation of the cost-effectiveness of chemical dust suppressant on unpaved haul roads in surface mines.

R & D project on characterization and control of dust in Naomundi iron ore mine of Tata Iron & Steel Company (TISCO), partially funded by TISCO, Naomundi. Characterisation of physical, chemical and mineralogical

properties of fugitive dust emanating from line sources in surface mines. Estimation of emission factor for vehicular traffic on unpaved haul road. Evaluation of the cost-effectiveness of chemical dust suppressant for line sources in surface mines.

1993   **R & D project on control of dust in Muraidih open cast project of Bharat Coking Coal Limited (BCCL)**, 1993, sponsored by Muraidih mine of BCCL, Dhanbad.Characterisation of physical, chemical and mineralogical properties of fugitive dust emanating from different sources in surface mines. Estimation of emission factor for vehicular traffic on unpaved haul road. Cost-effective evaluation of chemical dust suppressant from line sources in surface mines.

Presentation

Sinha Subrato and Banerjee S P. Respirable dust characterization in an Indian Open Cast coal mines, paper presented at 4th symposium on respirable dust in the mineral industry, organized by Department of Mineral Engg., Penn. State University, U.S.A. on behalf of the Generic Mineral Technology Centre for respirable dust, Pittsburgh, U.S.A., 8-10 Nov. 1994.

Sinha Subrato and Banerjee S P. A method for estimating fugitive particulate emission from haul roads in open cast coal mines and mitigation measures, paper presented in 2nd National Seminar on Mineral & Ecology, 7-8 Jan. 1994, Indian School of Mines, Dhanbad.

Sinha Subrato and Sridharan P V. Status of ambient noise environment in Neyveli region-A case study, paper presented in conference on Metrology in Relation to Environment, organised by Metrology Society of India in collaboration with National Physical Laboratory, 12-14 March 1997, New Delhi.

Sinha Subrato. The role of environmental monitoring in environmental management syatem, presented in trianing programme on Energy and Environment Audits, sponsored by Aisan Development Bank and Industrial Credit and Investment Corporation of India Limited, organised by TERI, 11-13 August 1997, New Delhi.

Sinha Subrato. Environmental impact assessment and management, presented in training programme for IAS officers on Management of the Environment, sponsored by Dept.of Personnel & Training, GOI, organised by TERI, 1-5 September 1997, New Delhi.

Noronha Ligia, Sridharan P V, Sinha Subrato . AEQM- A case study of iron ore mining in Goa. Presented in the Mega Event on Indian Mining Industry: A Perspective, organised by Department of Mines, 6-8 August 1998, Nagpur.

Sinha Subrato. Area-wide Environmental Quality Management Plan. Invited lecture at Central Pollution Control Board, 9 June 1998, New Delhi.

Sinha Subrato. Environmental impacts of mining activity. Presented in the workshop on AEQM report on the mining belt of Goa, organised by TERI, Goa, 10 July 1998.

Sinha Subrato. Area-wide environmental quality management plan (AEQM)-a concept for sustainable development. Presented in the National Workshop on Regional Environmental Management Plan, organised by TERI, New Delhi, sponsored by Monistry of Environment & Forests, Govt. of India, 25 November, 1998.

Publication

Sinha Subrato and Banerjee S P. 1993. Measurement and frequency analysis of noise emanating from some opencast mining machinery, Energy Environment Monitor,Vol.9(1): 15-29.

Sinha Subrato. 1995. Quantification of fugitive particulate emission from line sources in surface coal mines - an approach, Indian Journal of Environmental Protection, Vol.15, No.5, May.

Sinha Subrato and Banerjee S. P. 1996. Respirable dust characterisation in an Indian opencast coal mine. Applied Occupational and Environmental Hygiene, USA, 11(7), July, pp 771-778.

Sinha Subrato and Sridharan P. V. 1997. Ground level vibration in surface mines-An environmental concern. Indian Journal of Environmental Protection, March, pp 171-174.

Sinha Subrato and Banerjee S. P. 1996. Evaluation of the effectiveness of a chemical dust suppressant on haul road in an Indian opencast iron ore mine.The Indian Mining and Engineering Journal, 35 (12): 21-25.

Sinha Subrato and Banerjee S.P. 1997. Characterisation of haul road dust in an Indian opencast iron ore mine. Atmospheric Environment, UK, Vol.31, No.17, June, pp.2809-2814.

Sinha Subrato and Sridharan P V.1997. Status of ambient noise environment in Neyveli region-A case study. Journal of Metrology Society of India, Vol.12, No. 2-4, pp. 232-236.

Sinha Subrato and Bandhopadhyay T K. Review of trace elements in air environment and its health impacts in some Indian cities. Communicated to Jounel of Public Health and Engineering, 1998.

Sinha Subrato and Sridharan P V. Present and future assessment of noise level in Neyveli region. Communicated to Environmental Monitoring and Assessment, Netherlands, 1998.

Sinha Subrato and Sridharan P V. 1998. A study on respirable particulate matter in Neyveli region. Indian Journal of Environmental Protection, 18 (8): 573-576.

Sinha Subrato. 1998. Environmental impact assessment: an effective management tool.TERI Information Monitor on Environmental Science, 3(1):1-8.

9.2   **Language(s):** Good spoken and written English, Hindi and Bengali.

10.   **Certification:**
I certify the above to be a true and accurate description of my qualifications, experience, and language proficiency.

_____
Signature

$28-6-1999$
Date

CURRICULUM VITAE

Personal Information

Name	:	Prateek Sharma
Date of Birth	:	July 11, 1968
Current Employer	:	Tata Energy Research Institute
Current Position	:	Research Associate
Professional Designation	:	Environmental Engineer
Area of Specialisation	:	Environmental Systems Modelling

Profile in Brief

Ph.D in Civil Engineering (**Environmental Engineering**) from IIT Delhi with consistent brilliant academic record. Five (5) years of Research experience.

Summary of Qualification

1994 - 1999   **Indian Institute of Technology (IIT), Delhi**, Hauz Khas, New Delhi-110016, INDIA.

Ph.D. in Civil Engineering :   **Environmental Engineering (Air Quality Modelling)**

   Research Topic   .   Air Quality Modelling for an Urban Road Intersection
   of Delhi City.

- *Awarded Institute Fellowship throughout the study period.*

   Delhi College of Engineering, Delhi, Kashmere Gate, Delhi-110007.

1991 – 1993   **M.E. (Civil)**

- *Obtained 1st rank*
- *Awarded UGC Fellowship from 1991 – 1993*

1985 – 1989   **B.E. (Civil)**

Professional experience

1994 – 1998   **Indian Institute of Technology, Delhi**, Hauz Khas, New Delhi-110016
   Senior Research Fellow
   - Assistance in consultancy projects, preparation of project reports and project proposals, referencing, data analysis, demonstrator at undergraduate and post graduate level.

1991 – 1994   **Delhi College of Engineering, Delhi**, Kashmere Gate, Delhi-110006
   Junior Research Fellow & Visiting Lecturer
   Lecturing students of Civil Engineering, taking tutorial assignments and laboratory classes.

Publications in Journals/Conferences
Published/Accepted: 6   Communicated: 2

Papers Published/Accepted

1.   Khare, M., Sharma, P. and Shrivastava, A. (1996). Sick building syndrome in an educational institute library and laboratories. In: *Proceedings of the 7th International Conference on Indoor Air Quality and Climate* (Ed.: Ikeda, K. and Iwata, T.) **INDOOR AIR' 96**, SEEC ISHIBASHI INC., JAPAN, pp. 269-274.

2.   Khare, M., Sharma, P. (1997). Evaluating indoor air quality using CO2 as a surrogate index. *Australian Refrigeration Air Conditioning and Heating, AIRAH JOURNAL*, **51 (11)**, 29-38.

3.   Khare, M. and Sharma, P. (1999). Performance evaluation of general finite line source model for Delhi traffic conditions. *Transportation Research: Part D* **4**, 65-70.

4.   Sharma, P., Khare, M. and Chakrabarti, S.P. (1999). Application of extreme value theory for predicting violations of air quality standards for an urban road intersection. *Accepted for publication in Transportation Research: Part D* **4**, 201-216.

5.   Sharma, P. and Khare, M. (1999). Application of intervention analysis for assessing the effectiveness of CO-pollution control legislation in India. Accepted for publication in *Transportation Research :Part D*, Elsevier Science Ltd., UK.

6.   Sharma, P. and Khare, M. (1999). Real-time prediction of extreme ambient carbon monoxide concentrations due to vehicular exhaust emissions using univariate linear stochastic models. Accepted for publication in *Transportation Research: Part D*, Elsevier Science Ltd., UK.

Papers Communicated

1.   Sharma, P. and Khare, M. (1999). Estimation of air pollution concentration from an urban road intersection using empirically modified general finite line source model (e-GFLSM). Communicated to *Atmospheric Environment*, Elsevier Science Ltd., UK.

2.   Sharma, P. and Khare, M. (1999). Transfer function modelling technique to assess the impact of meteorological parameters on ambient carbon monoxide concentrations. Communicated to *Transportation Research: Part D*, Elsevier Science Ltd., UK.

Tata Energy Research Institute

1.	**Name**	Amit Kapur
2.	**Date of Birth**	August 13, 1973
3.	**Current Employer**	Tata Energy Research Institute
4.	**Years with Current Employer**	1.5years
5.	**Current Position**	Research Associate
6.	**Area of Specialization**	Environmental Monitoring and Analysis
7.	**General Qualifications**	

7.1 Education

- M.S, Environmental Engineering, Purdue University, 1997
- B.E, Civil Engineering, Delhi College of Engineering, 1995

7.2 General Experience:

September 1997 to date   Research Associate, Tata Energy Research Institute, New Delhi

8. Professional experience

- Environmental Impacts of Existing and Proposed Industries in Bhutan, National Environment Commission, Royal Government of Bhutan
- Preparation of a dossier on environmental impacts related to the use of Orimulsion® for power plants, M C Bitor Ltd
- Eco-Rating of Oil Pipelines, Indian Oil Corporation Limited
- Water quality transformations in distribution systems – An assessment of deterioration in water quality from source to end user, funded by UNDP-World Bank RWSG-SA
- Performance evaluation of sewage treatment plant and sludge bio-methanation - Study done for National Thermal Power Corporation Ltd., Vidyut Nagar.
- Industrial wastewater and sewage treatment design and solid waste management plan for Taj Trapezium - Techno-economic feasibility report prepared on behalf of Asian Development Bank.
- Environmental monitoring of Bull=s trench kilns, Swedish Development Corporation
- Eco-rating of cement units, GTZ
- Assessment of alternative environmentally sustainable sources of energy generation - A Yamuna river basin study, New Energy Development Corporation, Japan

8.2 Publications and Presentations

Papers :   2

- Hondzo, M., Kapur, A., and Lembi, C., A The effect of small-scale fluid motion on the green alga *Scenedesmus quadricauda, Hydrobiologia,*364:225-235, 1998.
- Kapur, A., Kansal, A., Prasad, R.K., and Gupta, S., Performance Evaluation of Sewage Treatment Plant and Sludge Bio-methanation, *Indian Journal of Environmental Protection,* 19 (2), 1999.

STATEMENT – IV

FACILITIES AVAILABLE AT INSTITUTION FOR CARRYING OUT THE PROJECT

Excellent facilities are available in the Institute for Laboratory studies, Computer network, Internet facilities, etc. It has a well-equipped laboratory with the state of art monitoring and analytical instruments for carrying out all environmental parameters. High volume sampler, respirable dust sampler, cascade impactor, personal dust sampler, stack monitoring kit, automatic weather monitoring instrument, atomic absorption spectrophotometer, gas chromatograph etc. are some of the instruments that are being used. A sophisticated and well established scientific laboratory is one of the major assets of the environmental group at TERI. Various tools namely mathematical models, GIS, advance statistical software, etc are some of the tools which are being extensively used by TERI as and when required.

APPENDIX TO THE APPLICATION FOR GRANT OF RESEARCH PROJECTS FOR THE ENVIRONMENTAL RESEARCH PROGRAMME

STATEMENT- V - Project Budget in the prescribed format

PROJECT BUDGET

A.	Salaries & Wages:	I Year	II Year	III Year	Total
	Investigator	83,490	1,39,150	1,66,980	3,89,620
	Co-investigator	83,490	1,11,320	83,490	2,78,300
	Research Associates	77,172	3,08,688	1,28,620	5,14,480
	Field Staff	0	2,00,000	0	2,00,000

Total: **Thirteen Lakh Eighty two thousand four hundred only. (Rs. 13,82,400)**

(The Monthly salaries for Investigator and Co-investigator are taken to be Rs. 27830 and those for Research Associates as Rs. 25,724).

B.   Permanent Equipment

High Volume Sampler (5)		2,25,000
Respirable Dust Sampler (2)		90,000
Weather Station (1)		2,50,000

Total: **Five Lakh Sixty Five thousand only. (Rs. 5,65,000)**

C.   Expendables

Sample Costs	5,04,000	(1008 Samples @ Rs. 500/sample)
Software Costs	30,000	

D.   Travel   2,10,000

E.   Other Project Costs if any:

Boarding / Lodging	4,80,000
Local travel	1,50,000
Instrument transportation	30,000

F.   Contingencies   20,000

G.   Institutional Charges

10% of Salaries and Wages   1,38,240

Grand Total: **Thirty Five Lakh Nine thousand six hundred and forty only. (Rs. 35,09,640)**

REFERENCES

Atkinson, Dennis (1999). Personal Communication, SCRAM, Support Center for Regulatory Models, Office of Air Quality Planning & Standards, U.S. Environmental protection Agency (e-mail: ATKINSON.DENNIS@epamail.epa.gov).

Axetell, K. and Cowherd, C. (1981). Improved emission factors for fugitive dust from western surface coal mining source (vol. II). Emission factors project ummary of EPA 68-03-2924. U.S. Environmental Protection Agency, Cincinnati, Ohio, PED Co., Inc., Kansas City, Midwest Research Institute.

Bjorklund, J.R. and Bowers, J.F. (1982a). User's instructions for the SHORTZ and LONGZ computer programs. Volume 1. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-903/9-82-004A (NTIS accession number PB 83-146 092).

Bjorklund, J.R. and Bowers, J.F. (1982b). User's instructions for the SHORTZ and LONGZ computer programs. Volume 2. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-903/9-82-004B (NTIS accession number PB 83-146 100).

Bowers, J.F., J.R., Bjorklund and Cheney, C.S. (1979a). Industrial Source Complex (ISC) Dispersion Model User's Guide, Volume 1. U.S. Environmental Protection Agency, Rserach Triangle Park, NC, EPA-450/4-79-030, (NTIS accession number PB 80-133 044).

Bowers, J.F., J.R., Bjorklund and Cheney, C.S. (1979b). Industrial Source Complex (ISC) Dispersion Model User's Guide, Volume 2. U.S. Environmental Protection Agency, Rserach Triangle Park, NC, EPA-450/4-79-031, (NTIS accession number PB 80-133 051).

Burt, E.W. (1977). Valley Model User's Guide. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-450/2-77-018, NTIS accession number PB 274-054.

Cole, C. E., B. L. Murphy, Jr., J. S. Evans, and A. Garsd (February 1985). *Quantification of Uncertainties in EPA's Fugitive Emissions and Modeling Methodology at Surface Coal Mines.* Project No. 2784-V12, TRC Environmental Consultants Inc., Englewood, Colorado.

Cox, W. M., and J. A. Tikvart (1990). "A Statistical Procedure for Determining the Best Performing Air Quality Simulation Model." *Atmospheric Environment,* 24A(9): 2387-2395.

Dailey, Bernard J. (1984). Internal Technical Memorandum, "Model Validation Study: Coal Mine Application." Wyoming Department of Environmental Quality, Cheyenne, WY, May 8.

Komp, Mark J., Donald F. Elias, Thomas M. Swain, and Mickey R. Meyers (1984). "Comparison of Two Air Quality Models (CDM and ISC) Predicted Concentrations for Surface Mining." Paper No. 84-15.4, presented at the 77th Annual Meeting of the Air Pollution Control Association, San Francisco, CA, June 24-29.

Muleski, G. E., G. Garman, and C. Cowherd, Jr. (1994). *Surface Coal Mine Emission Factor Study*. Draft Final Test Report, EPA Contract No. 68-DO-0123, Work Assignments 37 and 55, U.S. Environmental Protection Agency, Research Triangle Park, NC, January 17.

Perry, S.G., Thompson, R.S. and Petersen, W.B. Considerations for modelling small-particulate mpacts from surface coal-mming operations based on wind-tunnel simulations.

Petersen, W.B. (1978). User's Guide for PAL – A Gaussian Plume Algorithm for Point, Area and Line Sources. U.S. Environmental Protection Agency, Rserach Triangle Park, NC, Environmental Monitoring Series, EPA-600/4-78-013, NTIS accession number PB 281-306.

Pierce, T.E. and Turner, D.B. (1980). User's Guide for MPTER: A Multiple Point Gaussian Dispersion Algorithm With Optional Terrain Adjustment. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-600/8-80-016 (NTIS accession number PB 80-197 361).

Pierce, T.E., Turner, D.B., Catalano and Hale, F.V. (1982). PTPLU – A Single Source Gaussian Dispersion Algorithm with optional terrain adjustment. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-600/8-82-014 (NTIS accession number PB 83-211 235).

Rao, K.S. (1982). Analytical Solutions of A Gradient –Transfer Model For Plume Deposition and Sedimentation. . U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-600/8-82-079 (NTIS accession number PB 82-215 153).

Rao, K.S. and Satterfield (1982). MPTER-DS: The MPTER model including deposition and sedimentation. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-600/8-82-023 (NTIS accession number PB 83-117 739).

Rao, K.S. and Snodgrass, H.F. (1982). PAL-DS Model: The PAL Model Including Deposition and Sedimentation – User's Guide. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-600/8-82-023 (NTIS accession number PB 83-117 739).

Sawford, B.L. and Ross, D.G. (1985). Workshop on regulatory air quality modelling in Australia – 8th International Clean Air Conference. *Clean Air*, 19: 82-87.

Shearer, D. L., R. A. Dougherty, and C. C. Easterbrook (1981). *Coal Mining Emission Factor Development and Modeling Study,* TRC Environmental Consultants, July.

Sinha, S. (1994). Characterisation and control of haul road dust in open cast mines. *Ph.D. Thesis,* Indian School of Mines, Dhanbad, India.

Tikvart, J.A. (1991). Particulate matter from surface coal mining. (http://www.epa.gov/ttn/scram/guidance/mch/cfym48.txt)

Turner, D.B. and Busse, A.D. (1973). User's guide to the interactive versions of three point source dispersion programs: PTMAX, PTDIS and PTMTP. U.S. Environmental Protection Agency, Research Triangle Park, NC, (NTIS accession number PB 81-164 667).

Turner, D.B. and Novak, J.H. (1978a). User's Guide for RAM Volume 1. Algorithm Description and Use. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-600/8-78-016A (NTIS accession number PB 83-294 792).

Turner, D.B. and Novak, J.H. (1978b). User's Guide for RAM Volume 2. Data Preparation and Listings. U.S. Environmental Protection Agency, Research Triangle Park, NC, EPA-600/8-78-016A (NTIS accession number PB 83-294 792).

USEPA (1985/1986/1988/1990/1991). *Compilation of Air Pollution Emission Factors, AP-42,* 4th Edition, U.S. Environmental Protection Agency, Research Triangle Park, NC. Supplement A, October 1986. Supplement B, September 1988. Supplement C, September 1990. Supplement D, September 1991.

USEPA (1987a). *On-Site Meteorological Program Guidance for Regulatory Modeling Applications,* EPA-450/4-87-013, U.S. Environmental Protection Agency, Research Triangle Park, NC.

USEPA (1987a). *Ambient Monitoring Guidelines for Prevention of Significant Deterioration.* EPA-450/4-87-007, U.S. Environmental Protection Agency, Research Triangle Park, NC.

USEPA (1988). Control of Open Fugitive Dust Sources. EPA-450/3-88-008, U.S. Environmental Protection Agency, Research Triangle Park, NC, September.

USEPA (1992a). *Protocol for Determining the Best Performing Model.* EPA-454/R-92-025, U.S. Environmental Protection Agency, Research Triangle Park, NC.

USEPA (1992b). *User's Guide for the Industrial Source Complex (ISC2) Dispersion Models, Volume ICUser Instructions.* EPA-450/4-92-008a, U.S. Environmental Protection Agency ,Research Triangle Park, NC.

USEPA (1993). *User's Guide for the Model Evaluation Methodology (MEM) System for Comparing Model Performance, Version 1.0* (Draft). U.S. Environmental Protection Agency, Research Triangle Park, NC.

USEPA (1993). *Modeling Fugitive Dust Impacts from Surface Coal Mining OperationsXPhase I: Study Plan.* EPA Contract No. 68-D2-0159, Work Assignment.

USEPA (1994a). *Modeling Fugitive Dust Impacts from Surface Coal Mining Operations-Phase I.* EPA-454/R-94-024, U.S. Environmental Protection Agency, Research Triangle Park, NC. No. 8, Midwest Research Institute, Kansas City, MO, April 2.

USEPA (1994b). *Modeling Fugitive Dust Impacts from Surface Coal Mining Operations-Phase II*, EPA-454/R-94-024, U.S. Environmental Protection Agency, Research Triangle Park, NC. No. 8, Midwest Research Institute, Kansas City, MO, April 2.

USEPA (1994c). *Modeling Fugitive Dust Impacts from Surface Coal Mining Operations-Phase III.* EPA-454/R-94-024, U.S. Environmental Protection Agency, Research Triangle Park, NC. No. 8, Midwest Research Institute, Kansas City, MO, April 2.

Vardiman, S., and K. Winges (1991). *Powder River Basin Model Validation Analysis.* TRC Environmental Consultants, Englewood, CO, August 2.

Willmott, C.J. (1981). On the validation of models *Physical Geography* 2, 184-194.

Willmott, C.J., Ackleson, S.G., Davis, R.E., Feddema, J.J., Klink, K.M., Legates, D.R., O'Donnell, J. and Powe, C.M. (1985). Statistics for the evaluation and comparison of models. *Journal of Geophysical Research* 90, 8995-9005.

Yamartino, R. J. (1984). "A comparison of several 'single-pass' estimators of the Vstandard deviation of wind direction," *J. Climate Appl. Meteor.*, Vol. 23, pp. 1362-1366.

STANDARD US EPA SHORT-TERM AIR QUALITY MODELS

ISCST (Bowers et al., 1979 a, b)

The *industrial source complex short-term* model is a steady-state Gaussian plume model which can be used to assess pollutant concentrations from a wide variety of sources associated with an industrial source complex. This model can account for settling and drying deposition of particulates, downwash, area, line and volume sources, plume rise as a function of downwind distance, separation of point sources, and limited terrain adjustment. Average concentration or total deposition may be calculated in 1-, 2-, 3-, 4-, 6-, 12- and/or 24-hour time periods. An 'N'-day average concentration (or total deposition) or an average concentration (or total deposition) over the total number of hours may also be computed. Latest version of this model, the ISCST3, with powerful Windows interface has also come up. This model was developed to support the EPA's regulatory modelling options as specified in its *Guidelines on Air Quality Models*.

MPTER (Pierce and Turner, 1980)

MPTER is a *multiple point-source Gaussian model* with optional terrain adjustments. It estimates concentration on an hour-by-hour basis for relatively inert pollutants like sulphur dioxide (SO_2) and Total Suspended Particulate (TSP). MPTER uses Pasquil-Gifford (Pasquil, 1974) dispersion parameters and Briggs plume-rise methods (Ref.) to calculate the spreading and the rise of plumes. The model is most applicable for source-receptor distances less than 10 kilometres and for locations with level or gently rolling terrain. Terrain adjustments are restricted to receptors whose elevation is no higher than the lowest stack top. In addition to terrain adjustments, options are also available for wind-profile exponents, buoyancy-induced dispersion, gradual plume rise, stack downwash and plume half-life.

MPTDS (Rao, 1982; Rao and Satterfield, 1982)

MPTDS is a modification of MPTER to account explicitly for gravitational settling and/or deposition loss of a pollutant. Surface deposition fluxes can be printed under an optional output featyre. MPTDS is a multiple point source code with an optional terrain adjustment feature. The code is primarily based upon MPTER, which has Gaussian modelling assumptions. Execution is limited to maximum of 250 point souces and 180 receptors.

SHORTZ (Bjorklund and Bowers, 1982 a,b)

SHORTZ is designed to calculate the short-term pollutant concentration produced at a large number of receptors by emissions from multiple stack, building and area sources. SHORTZ uses sequential short-term (usually hour) meteorlogical inputs to calculate concentrations for averaging times ranging from one hour to one year. The model is applicable in areas of both flat and complex terrain, including areas where terrain elevations exceed stack-top elevations. The program requires random-access mass stroage capability.

VALLEY (Burt, 1977)

This algorithm is a steady-state, univariate Gaussian plume-dispersion model designed for estimating either 24-hour or annual concentrations resulting from emissions from up to fifty (total) point and area sources. Calculations of ground level pollutant concentrations are made for each frequency of ground level pollutant designated in an array defined by six stabilities, sixteen wind directions, and six wind speeds for 112 program-designed receptor sites on an radial grid of variable scale. Empirical dispersion coefficients are used and include adjustments for plume rise and limited mixing. Plume height is adjusted according to terrain elevations and stability classes.

PAL (Petersen, 1978)

This short-term Gaussian steady-state algorithm estimates concentrations of stable pollutants from point, area and line sources. Computations from area sources include effects of the edge of the source. Line source computations can include effects from a

variable emission rate along the source. The algorithm is not intended for application to entire urban areas but for smaller-scale analysis of such sources as shopping centres, air ports and single points. Hourly concentrations are estimated and average concentrtions from 1 hour to 24 hours can be obtained.

PALDS (Rao, 1982; Rao and Snodgrass, 1982)

PALDS calculates hourly concentrations from point, area and line sources. PALDS is a modification of PAL and has the capability to explicitly treat the effects of gravitational settling and/or deposition loss of pollutant on calculated concentrations. This is an optional feature. Surface deposition fluxes are also printed as output under this option. PALDS reads all input as data cards. Source input includes point, area, horizontal line, special line, horizontal curved path and special curved path data. All source input data are optional. Meteorology and receptor input data are also required.

PTPLU (Pierce et al., 1982)

PTPLU is a point-source Gaussian dispersion-screening model for estimating maximum surface concentrations for 1-hour concentrations. PTPLU is based on Briggs plume-rise methods and Pasquil-Gifford dispersion coefficients. It is an adaptation and improvement of **PTMAX** allowing for wind profile exponents and other optional calculations, such as buoyancy-induced dispersion, stack downwash and gradual plume rise. **PTPLU** produces an analysis of concentration as a function of wind speed and stability class for both wind speeds constant with height and wind speeds increasing with height. Use of the extrapolated wind speeds and other options allows the models user a more accurate selection of distances to maximum concentration. **PTPLUI** is the interactive version of this model.

RAM (Turner and Novak, 1978 a,b)

This short-term Gaussian steady-state algorithm estimates concentrations of stable pollutants from urban point and area sources. Hourly meteorological data are used, and hourly concentrations and averages over a number of hours can be estimated. The model uses Briggs plume rise and Pasquil-Gifford dispersion equations with dispersion

parameters for urban areas. Concentrations from area sources are treated by assuming that sources directly upwind are representative of area source emissions effecting the receptor. Special features include the determination of location of uniformly spaced receptors to ensure good area coverage with a minimum number of receptors.

PTMAX (Turner and Busse, 1973)

Performs an analysis of the maximum short-term concentrations from a single-point source as a function of stability and wind speed. The final plume rise and Pasquil-Gifford deposition methods to estimate hourly concentrations for stable pollutants. PTMAXI is the interactive version of this model.

PTDIS (Turner and Busse, 1973)

Estimates short-term concentrations directly downwind of a point source at distances specified by the user. The effect of limiting vertical dispersion by a mixing height can be included and gradual plume rise to the point of final rise is also considered. An option allows the calculation of isopleth half widths for specific concentrations at each downwind distance. Uses Briggs plume rise and Pasquil-Gifford deposition methods to estimate hourly concentrations for stable pollutants. PTDISI is the interactive version of this model.

PTMPT (Turner and Busse, 1973)

Estimates the concentration for a number of arbitrarily located receptor points at or above ground-level, from a number of point sources. Plume rise is determined for each source. Downwind and crosswind distances are determined for each source-receptor pair. Concentrations at a receptor from various sources are assumed additive. Hourly meteorological data are used: both hourly concentrations and averages over any averaging time from one hour to twenty-four hours can be obtained. Uses Briggs plume rise and Pasquil-Gifford deposition methods to estimate hourly concentrations for stable pollutants. PTMTPI is the interactive version of this model.